Michigan Department of Transportation

RESEARCH CENTERS OF EXCELLENCE

Center for Sustainable Infrastructure & Structural Testing

Lawrence Technological University

Mission and Facilities

The Center for Sustainable Infrastructure & Structural Testing conducts research, education and technology transfer activities related to corrosion mitigation and increased durability of bridges and structures. Under the leadership of Dr. Nabil Grace, the center utilizes a range of specialized laboratory equipment and facilities to evaluate the strength of concrete bridges, identify the causes of deterioration in bridge decks, develop innovative, long-lasting materials, and identify structures that are at high risk for failure.

Lawrence Technological University has the largest structures laboratory in Michigan. This allows the center to conduct full-scale testing of bridges, slabs and structures under large loads and extreme weather conditions. The researchers at the center are able to fabricate bridges in-house and simulate traffic flow, fire conditions, blowing wind and freezing rain.

Rapid-Response Services for MDOT

The center is available to support MDOT staff by providing quick-turnaround evaluation of materials and design concepts. For example, MDOT recently asked the center to investigate the fatigue life of a splice of rebar under 2 million cycles of repeated loading. Another request involved investigating the impact of splice length between two rebars. MDOT staff use the results of these investigations to enhance design and construction work.

The center also focuses on economical and practical methods for evaluating the strength of concrete bridge decks. The center recently completed a project for MDOT in which researchers identified the causes of concrete deterioration in bridge decks and developed a performance-based threshold and procedure to help MDOT staff identify those decks at high risk for falling concrete.

Although Lawrence Tech researchers specialize in research on long-term bridge life, the center also assists MDOT by investigating and developing innovative materials for use in short-term bridge repairs. For example, the center has worked with MDOT to apply a fiber-reinforced polymer (FRP) wrap to temporarily support deteriorating columns. The fix is inexpensive, fast and effective.

Additional services available include examining samples collected in the field, developing guidelines and recommendations for using FRP materials, inspecting bridge components in use, and offering training sessions for MDOT engineers.

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Research Centers of Excellence

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Lawrence Tech Engineering

MDOT

Michigan Department of Transportation

RESEARCH CENTERS OF EXCELLENCE

Center for Structural Durability

Michigan Technological University

Mission and Facilities

The Center for Structural Durability (CSD) was established in 2000 to provide research, education and technology transfer services for MDOT related to bridge durability. CSD researchers have expertise in materials science and structural engineering. Led by director Dr. Tess Ahlborn, the CSD investigates the use of ultra-high-performance concrete in structures, explores rapid construction approaches for prestressed concrete bridges, and monitors long-term durability through nondestructive methods like remote sensing.

The CSD is located at Michigan Technological University (MTU) in the Upper Peninsula. It is a resource for MDOT as well as local agencies and consultants. The Benedict Laboratory at MTU provides an expansive space for testing large concrete structures and a room specifically for mixing ultra-high-performance concrete. The CSD team also accesses a number of additional facilities and equipment on campus for preparing concrete specimens and analyzing the characteristics and performance of all materials.

Rapid-Response Services for MDOT

The CSD is available to provide MDOT staff with a range of quick-turnaround services such as software analysis and modeling, accelerated load testing, lab testing of high-performance concrete, and information gathering. Below are two examples of short-term projects carried out for MDOT.

- MDOT contacted the CSD in 2012 for help in assessing how spreadsheets developed by the Ohio Department of Transportation for performing load rating calculations for corrugated metal pipe culverts could be applied under Michigan conditions. The spreadsheets used both Load Factor Rating (LFR) and Load and Resistance Factor Rating (LRFR) methods. The CSD evaluated the spreadsheets for their adherence to reference guides and then modified them to function with Michigan truck loads (both legal and overweight). The resulting report is helping MDOT engineers better perform load ratings of culverts.

- The CSD helped MDOT create a nomination package to submit to the American Society of Civil Engineers to secure recognition of the Mackinac Bridge as a National Historic Civil Engineering Landmark. The CSD assisted in capturing the rich history of the bridge, from the design and construction of the structure to the individuals who were instrumental in pushing the project forward. The CSD is currently assisting with another bridge nomination package to help MDOT gain recognition for its significant structural accomplishments.

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Michigan Tech MDOT

Michigan Department of Transportation

RESEARCH CENTERS OF EXCELLENCE

Transportation Materials Research Center

Michigan Technological University

Mission and Facilities

Since 1998, the Transportation Materials Research Center (TMRC) at Michigan Technological University has provided MDOT with testing and analysis services related to concrete, asphalt, aggregates and soils. Dr. Stan Vitton manages the center, bringing years of experience in geotechnical, civil and mining engineering. The TMRC utilizes a number of advanced laboratories and pieces of equipment when responding to testing requests, such as:

- A large, multistory concrete laboratory accredited by the AASHTO Materials Reference Laboratory and the Cement and Concrete Reference Laboratory for testing large concrete structures.
- A concrete petrology laboratory that facilitates sophisticated environmental scanning, electron microscopy and mineralogy to identify concrete distress problems.
- A complete geotechnical soils investigation laboratory that supports testing related to resilient modulus for base, subbase and subgrade materials.
- High-strain rate testing equipment for concrete, asphalt and aggregates.
- Two asphalt laboratories for conducting a range of tests related to both warm-mix and hot-mix asphalt, binders, and coarse and fine aggregate properties.

Rapid-Response Services for MDOT

The TMRC readily responds to a range of requests from MDOT staff. For example, in 2012 MDOT staff asked the TMRC to investigate the accuracy and reliability of the Michigan Sand Cone Test, which is used to determine when a given soil will achieve its maximum dry density. MDOT also asked for help investigating the source of distress in pavement joints on M-14, analyzing the freeze-thaw properties of recycled concrete on I-75, studying the overall stability of the highway and slope of US-2 near Epoufette, and making recommendations on how best to stabilize an area experiencing erosion along M-25 in Sanilac County. The TMRC draws on the expertise of Michigan Tech faculty and graduate students to assist MDOT on an ongoing basis by:

- Conducting high-level analysis and microscopic examinations of pavement slab samples.
- Investigating slope failures resulting from erosion or blasting.
- Testing problematic materials in use on a construction project.
- Providing information about the geologic and geotechnical properties and aspects of construction sites.
- Investigating abandoned underground mines.
- Carrying out repetitive testing to validate MDOT's test methods.

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Research Centers of Excellence

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Michigan Tech MDOT

Michigan Department of Transportation

RESEARCH CENTERS OF EXCELLENCE

Pavement Research Center

Michigan State University

Mission and Facilities

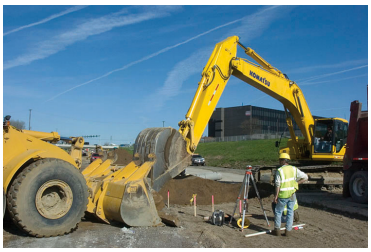
The Pavement Research Center of Excellence (PRCE) was established in 1995 at Michigan State University (MSU) to provide research, education and outreach related to pavements in Michigan. Director Dr. Karim Chatti works closely with faculty and graduate students to carry out a range of pavement-related activities, such as nondestructive testing of asphalt and concrete pavements, roughness characterization, pavement modeling, asphalt mix characterization, pavement performance testing, and preventive maintenance studies.

The PRCE carries out testing and analysis at two laboratories at MSU. The Civil Infrastructure Laboratory supports the evaluation of materials, pavements and structures with large-scale testing facilities and equipment. The asphalt laboratory is accredited by the AASHTO Materials Reference Laboratory. It supports investigations of the mechanical and physical properties of asphalt binders and mixtures to evaluate how they perform in the long-term under different loading and weather conditions.

Rapid-Response Services for MDOT

The PRCE has provided short-term assistance to MDOT staff by investigating drainage problems, substrate structure, and longevity properties of materials. MDOT staff also have turned to the PRCE for help capturing the state of the art on design issues, reviewing performance data for pavement management purposes, and observing pavement performance in the field alongside MDOT engineers.

The PRCE recently conducted a one-day short course related to mechanistic-empirical pavement design to support implementation at MDOT. Additional short courses are available to MDOT staff, based on existing needs. Potential topics include:



- Design of new and rehabilitated asphalt and concrete pavements.
- Rehabilitation of asphalt and concrete pavements.
- Cost-effective pavement preservation policies and practices.
- Maintenance and pavement management systems.
- Role of material characterization in improving pavement performance.
- Best practices for in-place asphalt pavement recycling.
- Use of reclaimed asphalt pavement in hot-mix asphalt layers.
- Quality control and quality assurance to improve highway construction.
- Sustainable road construction and materials.

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Research Centers of Excellence

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MICHIGAN STATE UNIVERSITY | College of Engineering

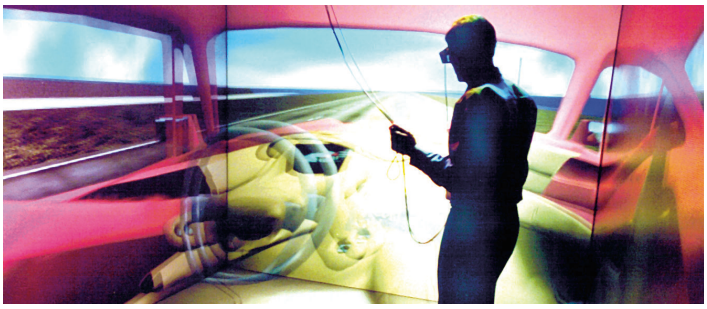
MDOT

Michigan Department of Transportation

RESEARCH CENTERS OF EXCELLENCE

Bridges and Structures Research Center

University of Michigan



Mission and Facilities

The Bridges and Structures Research Center at the University of Michigan focuses on finding innovative, effective and practical solutions to problems related to bridges and structures. Under the direction of Dr. Sherif El-Tawil, the center evaluates new technologies developed by MDOT and supports the development of new materials, components and tools for advancing the preservation and safety of transportation infrastructure.

The center utilizes state-of-the-art facilities and equipment at the university, including a structural engineering laboratory for testing large-scale elements and a computational structural simulation laboratory that supports sophisticated modeling of how structural materials and components will behave under different conditions. The university also boasts one of only a few 3-D visualization laboratories in the country, which can be used for immersive visualizations of models involving intersections, construction sites and structures. The CAVE (Cave Automatic Virtual Environment) includes unrestricted navigation (walking, flying, looking), interaction with virtual objects, and directional sound.

Rapid-Response Services for MDOT

In 2012, the center team met with MDOT staff to present the latest information about ultra-high-performance concrete (UHPC). This specially formulated concrete is capable of achieving high compressive and tensile strength, exceptional energy absorption and durability, and self-healing properties when properly developed and reinforced with steel fibers. The center developed the first non-proprietary UHPC in the United States and is working with MDOT to identify the most effective means for utilizing the new material.

The center also responds to MDOT requests for testing and simulation on an ongoing basis. For example, the center recently provided MDOT research staff with guidance on how to model the response of abutment walls with battered piles. Below are other examples of the services available to MDOT staff through the center.

- Finite element modeling of structural components and systems.
- Evaluation and assessment of bridge systems and components.
- Assessment of the serviceability of structures.
- Assistance with implementation of research findings.
- Full-scale testing of bridge components or systems.
- High-fidelity finite element simulations.

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UNIVERSITY OF MICHIGAN MDOT

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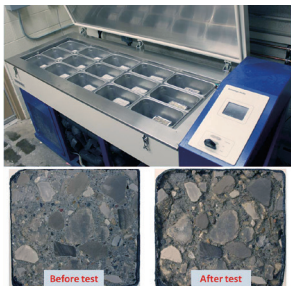
RESEARCH CENTERS OF EXCELLENCE

Concrete Pavement Performance Center

University of Michigan

Mission and Facilities



The Concrete Pavement Performance (CPP) Center at the University of Michigan (U of M) provides technical assistance to MDOT related to the performance of in-service concrete pavements. Under the leadership of Dr. Will Hansen, the CPP conducts forensic investigations of pavement performance, develops surface treatments that extend pavement life, and studies the impact of environmental distress on concrete.

The CPP uses state-of-the-art research equipment for carrying out testing, such as digital microscopes for determining the quality of the concrete, exposure systems for measuring deterioration from salt and frost, a mechanical tester for measuring the strength of concrete, a specialized dilatometer for measuring contraction and expansion of concrete during freeze-thaw cycles, and equipment for determining the resistance of concrete to cracking during heating and cooling.

Rapid-Response Services for MDOT

The CPP carries out both laboratory and field investigations for MDOT on an ongoing basis, such as:

- Conducting forensic investigations into the factors influencing performance of unbonded overlays and jointed plain concrete pavement.
- Developing procedures for finite element analysis and mechanistic-empirical pavement design.
- Studying air-void systems in concrete and their impact on durability.
- Using cryogenic dilation of concrete to measure expansion and contraction associated with freezing and thawing.
- Developing recommendations for combating premature deterioration and other impacts of environmental distress.

In 2012, MDOT staff asked the CPP to investigate the impact of a variety of surface treatments on concrete durability on M-14 using freeze-thaw salt-scaling tests. The MDOT/CPP team developed a poster on the study results for presentation to MDOT staff and U of M students. MDOT staff also asked the CPP to determine how varying cementitious blends and admixtures affect heat development at different temperatures. The CPP is working closely with MDOT staff to incorporate the results into pavement design practices.

In addition, the CPP has begun developing a new cementitious blend for rapid repair concrete applications by experimenting with different types of cements and admixtures. MDOT's goal is to make concrete repairs that are strong enough to withstand traffic within six hours of application. The CPP also is working with MDOT engineers to investigate how to accelerate the curing of rapid repair concrete in colder temperatures when the summer heat is not available to aid the process.

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UNIVERSITY OF MICHIGAN MDOT

Michigan Department of Transportation

RESEARCH CENTERS OF EXCELLENCE

Center for Structural Durability

Western Michigan University

Mission and Facilities

The Center for Structural Durability at Western Michigan University (WMU) evaluates the materials, design, construction, repair and maintenance of highway structures to improve their durability and prolong service life. Led by Dr. Haluk Aktan, the center specializes in performing computer simulations and nondestructive evaluation (NDE) of bridge elements. Using a range of equipment, such as ground-penetrating radar, ultrasonic systems, laser trackers and laser scanners, the center team investigates how structures are performing without damaging them.

Rapid-Response Services for MDOT

The center responds to ongoing requests from MDOT staff to assist with evaluating the conditions of structures in the field. For example, MDOT staff contracted with the center for assistance in determining why certain concrete bridges were cracking. The team developed finely detailed computer models to demonstrate the range of scenarios that could be causing the problem, and MDOT used the results to develop a plan for addressing the damaged structures.

Beyond conducting field evaluations and computer simulation, the center provides guidance and support to MDOT staff involved in evaluating structural components or monitoring bridge health. The center is also available to assess approaches proposed by researchers for using NDE methods as part of new research projects.

The center is currently working with MDOT to develop a process for implementing accelerated bridge construction (ABC), a bridge replacement method in which the bridge components are built off-site and assembled or moved into place. The process is appealing because it reduces road closure time from months to weeks. The center evaluates a range of materials used for connecting and sealing bridge components and recommends materials that will support long-term durability. The team also has the capability to review and evaluate plans submitted by contractors for ABC and provide site-specific implementation advice.

In 2012, the center held a workshop on ABC design and lessons learned for bridge engineers, contractors and project managers. Presenters at the workshop included Dr. Aktan, WSU faculty members, MDOT engineers and FHWA representatives. More than 50 people participated. Dr. Aktan and his team are available to develop and lead additional seminars or workshops on bridge-related topics requested by MDOT.

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Michigan Department of Transportation

RESEARCH CENTERS OF EXCELLENCE

Center for Bridges & Structures Research

Michigan State University

Mission and Facilities

The Center for Bridges & Structures Research at Michigan State University (MSU), directed by Dr. Rigoberto Burgueño, is dedicated to advancing the performance and durability of highway structures in Michigan through research and technology transfer activities. The center explores innovative approaches to materials, design, construction, repair and maintenance of highway structures to extend the time between maintenance applications and prolong overall service life.

The center has access to the Civil Infrastructure Laboratory at MSU, a modern facility that supports both small-scale and large-scale testing of structures and pavements. Researchers can simulate mechanical and environmental loading capabilities when evaluating new concrete technology, proposed repairs and the effects of early-age damage in bridges.

Rapid-Response Services for MDOT

The center offers expertise in fiber-reinforced polymer (FRP) composite materials, which can be used to strengthen and rehabilitate existing structures as well as for new bridge designs. The center is prepared to assist in:

- Specification development for FRP composite materials.
- Design of FRP composites for new construction.
- Testing of FRP composite and other materials and characterization of short- and long-term behavior.
- Evaluation of FRP composite and other advanced materials at very small (nano) scales and very large scales.

The center is also capable of assisting MDOT in developing innovative bridge systems for the future using finite element modeling and analysis and experimental characterization of high-performance concrete materials and structures.

To assist in management and maintenance of MDOT's existing bridge system, the center has testing, monitoring and analytical capabilities in the following areas:

- Evaluation of structural defects and failures.
- Sensor technology and structural health monitoring.
- Precast/prestressed bridge elements and systems.
- Sensor technology and structural health monitoring methods.
- Degradation models for reinforced concrete structures that utilize probability-based approaches, solid mechanics approaches, and artificial intelligence methods.
- Bridge management models and algorithms.
- Testing of bridge components and systems under extreme loads and temperatures.

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